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GUIDELINES FOR CONSTRUCTION OF ROLLER COMPACTED CONCRETE PAVEMENTS

(First Revision)

INDIAN ROADS CONGRESS

2022

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GUIDELINES FOR CONSTRUCTION OF ROLLER COMPACTED CONCRETE PAVEMENTS

1. INTRODUCTION

1.1 The Revised Draft of IRC:SP:68 "Guidelines for Construction of Roller Compacted Concrete Pavements" *(First Revision)* was prepared by Sub Group comprising of Shri R.K Jain, Shri Binod Kumar, Shri M.C Venkatesha and Shri Raman Kumar members of Rigid Pavement Committee (H-3). The draft was deliberated in several meetings of H-3 Committee and was finalized in its meeting held on 19.05.2022.

The composition of the H-3 Committee is as given below:

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1.2 The revised draft document was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 04.06.2022. The HSS Committee approved this document subject to suitably incorporating written and verbal comments received and also recommended it for placing before the meetings of Executive Committee (EC) and Council. The EC in its meeting held on 16.06.2022 approved the draft document for placing before the Council. The 222nd Mid-Term Council in its meeting held on 17th – 18th June, 2022 at Shillong (Meghalaya) considered and approved the draft "Guidelines for Construction of Roller Compacted Concrete Pavements" for printing.

2. SCOPE

Roller Compacted Concrete Pavements (RCCP) are intended for use in the construction of low volume roads with average daily traffic less than 450 commercial vehicles per day. RCCP can also be used for forest roads, parking area, shoulders of pavement etc. The RCCP construction is done using equipment like concrete pavers used for laying dry lean concrete (DLC) or bituminous pavers fitted with tamping bars for initial compaction and sensors for controlling level, vibratory roller and concrete mixers/batching plants. The final finished surface of RCCP is not as smooth as the conventional paver-laid concrete pavement. Maximum permissible values of roughness of RCCP shall be 3200 mm/km. Whenever situation warrants for improving riding quality, appropriate bituminous wearing course may be provided as per MoRD specification.

For roads where speed of vehicles is not an essential attribute, as in the case of low-volume Rural Roads, RCCP without bituminous surfacing is a good choice. As RCCP has to support the weight of the vibratory roller, the mix has to be sufficiently dry.

RCCP shoulders should be used only with mainline rigid pavement or roller compacted concrete pavements. The thickness of RCCP shoulders including its foundation layers should be the same as that of the mainline pavement.

The minimum characteristic compressive strength of RCCP will normally be 30 MPa with minimum flexural strength of 3.8 MPa at 28 days. The subgrade CBR will be not less than 5%. The thickness of subgrade will be minimum 300 mm.

3. MATERIALS

3.1 Cement

Any of the following types of cement may be used:

(i) Ordinary Portland Cement IS: 269 (43 grade and 53 grade)

(ii) Portland- Pozzolana Cement IS: 1489 (Part-I)

(iii) Portland Slag Cement IS: 455.

Composite cement having compressive strength of 43 MPa at 28 days may also be used.

The quantity of cement used in RCCP shall be as per mix design approved by the Engineer.

If the pavement is likely to rest on a soil subgrade having soluble sulphates in a concentration of more than 0.5 percent, cement used shall be sulphate resistant and shall conform to IS:12230. Cement may be obtained in bulk form or in bags. If paper bags are proposed to be used, there shall be bag splitters with the facility to separate pieces of paper bags and they shall be disposed off suitably. No paper pieces shall enter the concrete mix. Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage silos are used, their capacity should be sufficient to cater to the requirement at site and they should be cleaned at least once in every 3 to 4 months.

Each consignment of cement shall be stored separately so that it is readily identifiable and the material can be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which has deteriorated in any way, during transportation and storage, shall not be used in the works.

3.2 Fly-ash

When Fly-ash is used in RCCP mix, it shall conform to the Bureau of Indian Standards Specifications, IS: 3812 (Grade-I). The physical requirements shall conform to **Table 1**. IS: 3812 (Part-I). The percentage of fly ash by weight of cementitious material shall be up to 25 percent.

Table 1 Physical Requirements of Fly-ash (As per IS: 3812)

Sl. No.	Characteristics	Requirements
(i)	Fineness, Specific surface area in m^2/kg, by Blaine's permeability method, minimum	320
(ii)	Particles retained on 45 micron IS sieve, per cent maximum	34
(iii)	Lime Reactivity, average compressive strength, N/mm^2, Minimum	4.5
(iv)	Soundness by autoclave test expansion of specimen in per cent maximum	0.8
(v)	Drying shrinkage per cent, maximum	0.15

Fly-ash shall be transported in covered trucks, and slightly sprinkled with water, to avoid dust nuisance. Excessive stock-piling of fly-ash at site shall be avoided, and its supply regulated to match with the consumption.

In case stock-piling becomes unavoidable, adequate precautions shall be taken to prevent dusting by covering the stockpiles with tarpaulin.

The properties of fly-ash shall be tested at regular intervals. At least one set of tests prescribed in IS: 3812 shall be carried out once for each consignment.

3.3 Ground Granulated Blast Furnace Slag (GGBFS)

Factory manufactured ground granulated blast furnace slag upto 40 percent by weight of cementitious material may be mixed at site with Ordinary Portland Cement of 43/53 Grade. GGBFS shall conform to IS:16714. Regular tests shall be conducted on GGBFS at a testing frequency of one test per 100 MT of slag to ensure the quality.

3.4 Aggregates

3.4.1 Aggregates for RCCP shall be natural material complying with IS: 383. The aggregates shall not be alkali-reactive. In case the aggregates are not found to be free from dirt, they may be washed, drained for at least 72 hours and dried before batching. Such aggregates shall be checked for water absorption before using them so that requirement of water proposed in the design mix could be adjusted.

3.4.2 *Coarse Aggregates*

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel with minimum three fractured faces and shall be devoid of pieces of disintegrated stone, and soft, flaky, elongated, very angular or splintery pieces. The coarse aggregates shall not have a combined flakiness and elongation index of more than 40 percent. The maximum size of the coarse aggregates shall not exceed 26.5 mm. Water absorption of the aggregates shall be 3% maximum. However, aggregates with water absorption more than 3 percent may be used after conducting the soundness test in accordance with IS: 2386 (Part V). After 5 cycles of testing, the loss shall not be more than 12 percent if sodium sulphate solution is

used or 18 percent if magnesium sulphate solution is used. Aggregates having water absorption more than 5% shall not be used. Aggregate Impact Value (AIV) shall not be more than 30%. Aggregate Los Angeles abrasion value shall not be more than 35%.

Coarse aggregates shall be delivered at site in two separate sizes. They shall be dumped and stacked over a firm and leveled ground. The stackyard shall have adequate surface drainage arrangement so that water does not stagnate below the aggregates. Aggregates placed on the ground shall not be removed from the stockpile within 300 mm from the ground until the end of the work. The aggregates from the bottom layer shall be permitted for use after cleaning the aggregates by screening/washing and drying as directed by the Engineer.

3.4.3 *Fine Aggregates*

Fine aggregates shall consist of clean, natural sand or crushed stone sand or a combination of the two. Fine aggregate shall be free from soft particles, clay, shale, loam, mica, organic and other foreign matter. The fine aggregates shall not contain deleterious substances more than the following:

Clay lumps : 1.0 percent

Coal and lignite : 1.0 percent

Material Passing 75 Micron Sieve: 3.0 percent in natural sand and 8 percent in crushed sand.

Crushed sand enhances the aggregate interlock whereas a small portion of natural sand helps to improve the workability of RCCP mix. Therefore, use of blended sand with a higher percentage of crushed sand is desirable.

3.4.4 *Blending of Aggregates*

The coarse and fine aggregates shall be blended so that the material after blending shall conform to the grading given in **Table 2**.

Table 2 Aggregate Gradation for RCCP

Sieve Designation (mm)	Percentage passing the sieve by weight
26.5	100
19.0	75-95
9.5	50-70
4.75	30-55
2.36	17-42
600 micron	8-22
300 micron	7-17
150 micron	2-12
75 micron (Wet Sieving)	0-8

3.4.5 *Water*

Water used for mixing and curing shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS: 456.

4. MIX DESIGN

4.1 Mix design procedure for RCCP is different from the design of mix for a conventional cement concrete pavement as RCCP is a no-slump concrete.

The mix shall be proportioned by weight of all ingredients such that the desired target mean strength is achieved. The mix design shall be based on the flexural strength of concrete. The moisture content shall be selected so that the mix is dry enough to support the weight of a vibratory roller, and yet wet enough to permit adequate distribution of paste throughout the mass during mixing, laying and compaction operations. The water content by weight may be in the range of 5-8 percent by weight of dry mix and shall be determined by trial mixes by changing water content at intervals of 0.5 percent. The optimum moisture content which gives the maximum density shall be determined. The moisture content of the mix may be kept 1-2% higher than the optimum moisture content. The extra moisture is to compensate for loss due to evaporation during transportation of mix to paving site. The volume of sand and coarse aggregate shall be varied to optimize the strength by trials. The fly-ash/cement ratio shall be selected so as to achieve the required strength. Fly-ash quantity shall be 25 percent by weight of cementitious material. GGBFS up to 40% by weight of cementitious material can also be used. These minerals additives are added to enhance the strength and durability of RCCP. The minimum cementitious material content shall be 350 kg/m^3. The cementitious material content can be increased, if needed, to get the required designed strength of RCCP.

Using the proportion of coarse aggregates, fine aggregates, water, cement and fly-ash/GGBFS so established, a trial length is constructed to demonstrate satisfactory performance of the mix and the construction equipment proposed to be used.

4.2 Mix Design Steps

The soil-compaction method is the most commonly used for designing mixes of RCCP. The design procedure involves the following steps:

4.2.1 *Selection of Well-Graded Aggregates*

A maximum density grading is targeted for the combined aggregate gradation as per **Table 2**.

4.2.2 *Selection of Cementitious Content*

The second step is to determine the cementitious material content. The first trial may be started with 14-18 percent cementitious material by weight of dry materials, i.e., cementitious materials and dry aggregate. Strength requirement of the mix will be the main factor for selecting cementitious material requirements.

4.2.3 *Development of Moisture-Density Relationship*

Moisture-density relationship is developed for each cementitious material content by performing modified Proctor compaction tests at various moisture contents in the range of 5-8%. The dry density is plotted on Y-axis against moisture content on X-axis to determine the Maximum Dry Density (MDD). The MDD is then used to determine the proportions of cementitious materials and aggregate. The Optimum Moisture Content (OMC) corresponding to MDD is used to determine the total moisture content of the mix.

4.2.4 *Casting Specimens for Strength Measurement*

Cube and beam specimens are prepared for testing compressive and flexural strength to comply with the mix requirement. The specimens can be cast using a footed vibratory hammer.

4.2.5 *Specimen Testing*

Concrete cube and beam specimens are tested to determine the compressive and flexural strength of the mix. The strength achieved on testing is compared with the required strength for the project to determine compliance. If this strength meets the criteria of required strength then the cement content selected for the mix is final. If, strength criteria is not met, then cement content is increased and all the above steps are repeated untill the strength criteria is fulfilled.

4.2.6 *Calculation of Mix Proportion*

The last step is to determine the mix proportions based on the MDD and OMC of the mix which satisfies the strength requirement.

An example of determining the mix proportion is given in **Appendix-I**. A typical mix proportion of RCCP is given in **Table 3**.

Table 3 A Typical Mix Proportion for RCCP

Ingredient	Quantity, kg/m^3
Water	154
Total Cementitious Material (Cement+FA/GGBFS)	380
Cement	285
Fly-Ash	95
Fine Aggregate	898
Coarse Aggregate	1097

5. THICKNESS DESIGN

The thickness design of RCCP will be carried out on the basis of critical edge load stresses and edge temperature stresses as per the procedures recommended in IRC:SP:62. A typical cross section of RCCP is given in **Fig. 1**.

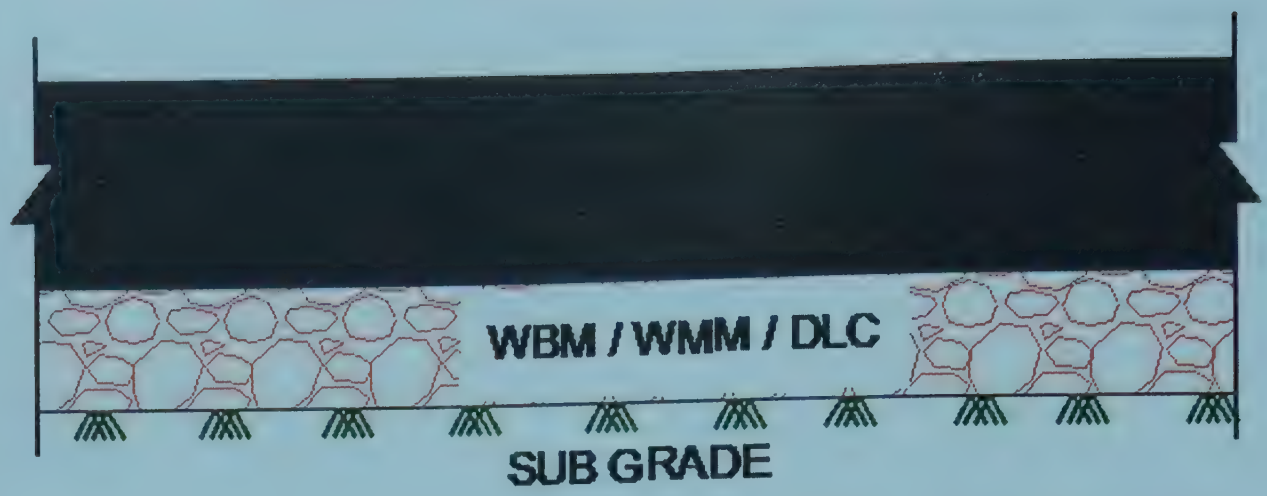

Fig. 1 Typical Cross Section of Roller Compacted Concrete Pavement

6. CONSTRUCTION

6.1 Trial Length

A trial length of at least 30 m shall be constructed officially outside the main works. The Contractor shall construct trial length away from the carriageway for refining his construction methodology, suitability of his equipment, determination of surcharge etc. In case the Contractor fails to construct satisfactorily trial length, he shall repeat trials till he is able to construct a satisfactory trial length. The moisture content determined in the laboratory mix design shall be tried and the rolling equipment shall be deployed to determine the number of passes required to achieve the maximum density. After the construction of the trial length, the in-situ density of the freshly laid mix shall be determined by sand replacement method with 150 mm diameter density holes as per IS 2720 (Part 28). Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length; and an average of three densities shall be determined. These main density holes shall not be made in the strip 500 mm from the edges. During trial length construction, the loose thickness of mix required for achieving designed thickness after compaction shall be established. The optimum moisture content determined in the laboratory mix design plus 1-2% shall be tried and adjusted in the site to have a satisfactory mix for RCCP. The field density obtained during day-to-day construction shall be compared with this reference density determined in trial length construction. The density of RCCP in the central portion i.e. leaving 0.5 m of edge strips shall not be less than 98% and density in edge strips of 0.5 m width shall not be less than 96%.

The pavement constructed in trial length shall be cut over 1.0 m width and reversed to inspect the condition of concrete at the bottom surface to check whether there is any segregation taking place. If segregation is noticed, some adjustment in the mix proportion may have to be carried out till satisfactory trial length pavement is constructed without any segregation.

After the approval of the trial length, the main work shall proceed with the materials, mix proportions, moisture content, mixing, laying and established number of passes of roller and construction procedures.

6.2 Batching and Mixing

The batching and mixing shall be done in a batching plant, preferably with pan mixer, capable of proportioning the materials by weight, where each type of material being weighed separately. **Photo 1** shows a batching plant with pan mixer. The capacity of the batching and mixing plant shall be at least 25 percent higher than the proposed capacity for laying the pavement such that paver shall not stop frequently for want of supply of mix. Frequent stopping of paver will affect the riding quality of the pavement. The batching and mixing shall be carried out preferably in a forced-action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. For small jobs, concrete mixers of at least of 0.4/0.3 cum (14/10 cft) capacity may be used, provided a reliable weigh batching arrangement is provided. Pan mixers may also be used. The weighing balances shall be calibrated by weighing the aggregates, cement, fly-ash/ GGBFS and water on a large weighing machine. The accuracy of the weighing scales of the batching plant shall be within ± 2 percent in the case of aggregates and ± 1 percent in the case of cement, fly-ash/GGBFS and water. The batching plant shall be such that it can be shifted from place to place easily as the work progresses.

There shall be close communication between the staff at Mixing Plant and the Paving Site either through radio or mobile phone for controlling the quality of the concrete mix.

The contractor shall keep the foundation of Batching Plant ready in advance in the next location so that minimum time is taken for shifting the Plant to the next location without affecting the progress of work.

Photo 1 Batching Plant with Pan Mixer

6.3 Transporting

Concrete shall be discharged from the mixer and transported directly to the point where it is to be laid by tipping trucks covered with tarpaulin. **Photo 2** shows the concrete from tipper being transferred in front of the paver. The capacity of the transport trucks shall be 25% above the production capacity of the batching plant and the laying capacity of the paver to ensure construction to proceed at an uniform speed in an uninterrupted manner.

Photo 2 Concrete Transported by Tipper and Placed in Paver Hopper

6.4 Laying

The concrete shall be laid by a paver having sensors that can pave to the design level. **Photo 3** shows the paving of RCCP with a bituminous paver. The paver shall be capable of laying the mix in one layer in an even manner without segregation, so that after compaction, the total thickness shall be as specified. Frequent stopping and starting should be avoided.

The laying of the two-lane road may be done either in full width or lane by lane. If the lane by lane paving is adopted, it is preferable if two paving machines are used in echelon one immediately behind the other so that the joint is well compacted when the mix is green and has not set. The concreting of the second lane should be done as quickly as possible within 90 minutes of placing concrete mix in the first lane.

Photo 3 RCCP Laying with Bituminous Paver

6.5 Camber

For the purpose of quick surface drainage of pavement, camber is required to be provided. The modern pavers have a central hinge for adjusting main paver plate to required camber. Normally 2% camber is given in the case of concrete pavements.

6.6 Compaction

Compaction shall be carried out immediately after the material is laid and leveled. The time between placing and the beginning of rolling operations should not be more than 10 minutes.

Rolling shall be done with a double drum vibratory roller with smooth wheels and weight of 80-100 KN or more as shown in **Photo 4**. The number of passes required to obtain the maximum compaction shall be determined by measuring the in-situ density during the trial construction.

Photo 4 Compaction of RCCP with Vibratory Roller

In addition to the number of passes required for compaction, there shall be a preliminary pass without vibration to bed the concrete down, and again a final pass without vibration to remove the roller marks and to smoothen the surface.

The spreading, compacting and finishing of the concrete pavement shall be carried out as rapidly as possible and the operation shall be so arranged so as to ensure that the time between the mixing of the first batch of concrete and the final finishing of the same shall not exceed 60 minutes when the concrete temperature is between 25°C and 30°C and 90 minutes if temperature is less than 25°C. This period may be reviewed in light of the results of the trial run, but in no case shall it exceed 2-hours. Work shall not proceed when the temperature of the concrete exceeds 30°C. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. The concreting shall be stopped when the ambient temperature is above 35°C.

After compaction has been completed, the roller shall not stand on the compacted surface for the duration of the curing period, except during commencement of next day's work near the location where the work was terminated the previous day.

If the RCCP is too wet or too dry for compaction upon laying, the water content shall be adjusted at the plant to correct this. Only minor changes in water content from the design mix should be made; otherwise a new mix design may be needed.

Rolling shall begin from the edges progressing gradually towards the center whether it is a single-lane road or two-lane road. The vibratory rolling should commence at the outer edge of the first paving lane, so that the rolling wheel extends over the edge of the pavement by 25-50 mm to confine the mix and prevent excessive lateral displacement of the concrete mix upon further rolling. Two passes are given in this position. The roller should then shift to within 300-450 mm of the interior edge in the case of lane by lane paving and make two passes. This will leave an uncompacted edge to set the height of the screed for an adjacent lane and allows both the lanes of the fresh joint to be compacted simultaneously. The uncompacted material in the center of the lane should then be compacted with two passes of the roller with vibration. The pattern shall be repeated to make a total of four passes on the lane, or more if the specified density is not achieved. Rolling sequence for first lane is given in **Fig. 2**.

In case of two-lane RCCP, when the adjacent lane is placed, two passes should extend 25-50 mm over the outer edge of this adjacent lane. The fresh joint between the first lane and the second lane is then compacted including 300-350 mm of first lane which was left uncompacted as well as the remaining width of the second lane in the same manner with two passes. Any remaining uncompacted material in the second lane should be rolled with two passes of the roller. This pattern should be repeated to make a total of four passes minimum over the RCCP material. Additional passes over the fresh joint between the two lanes may be necessary to ensure smoothness and density across the joint. The rolling sequence for second lane is shown in **Fig. 3**. The loose edges of the pavement are then trimmed to form a vertical face preferably with grader blade.

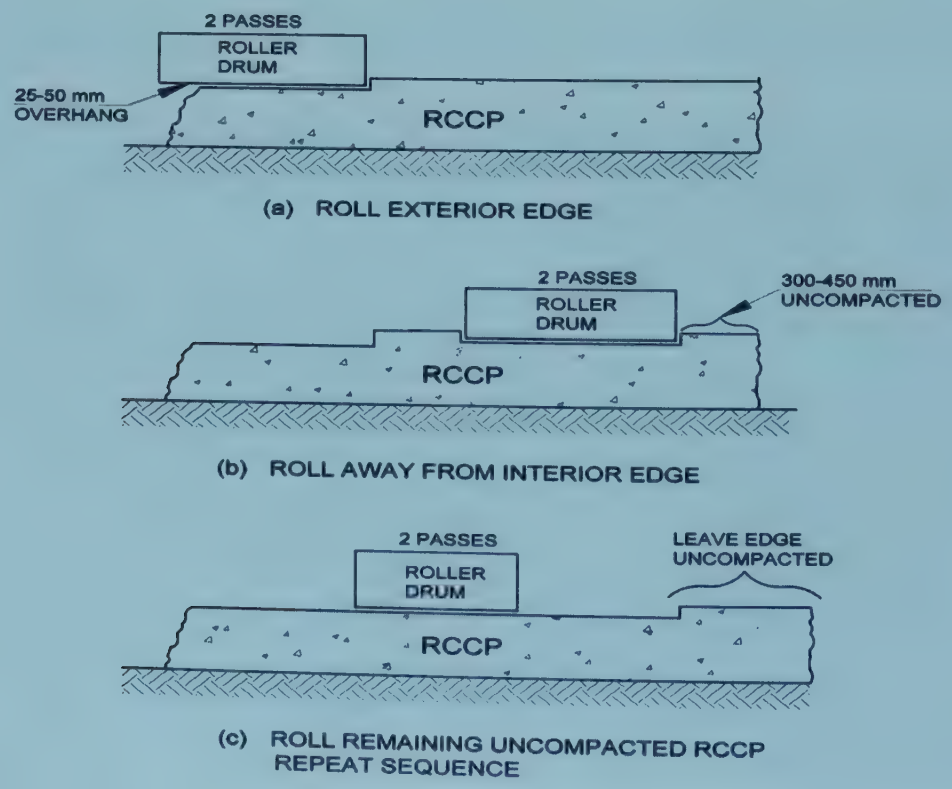

Fig. 2 Rolling Sequence for First Lane

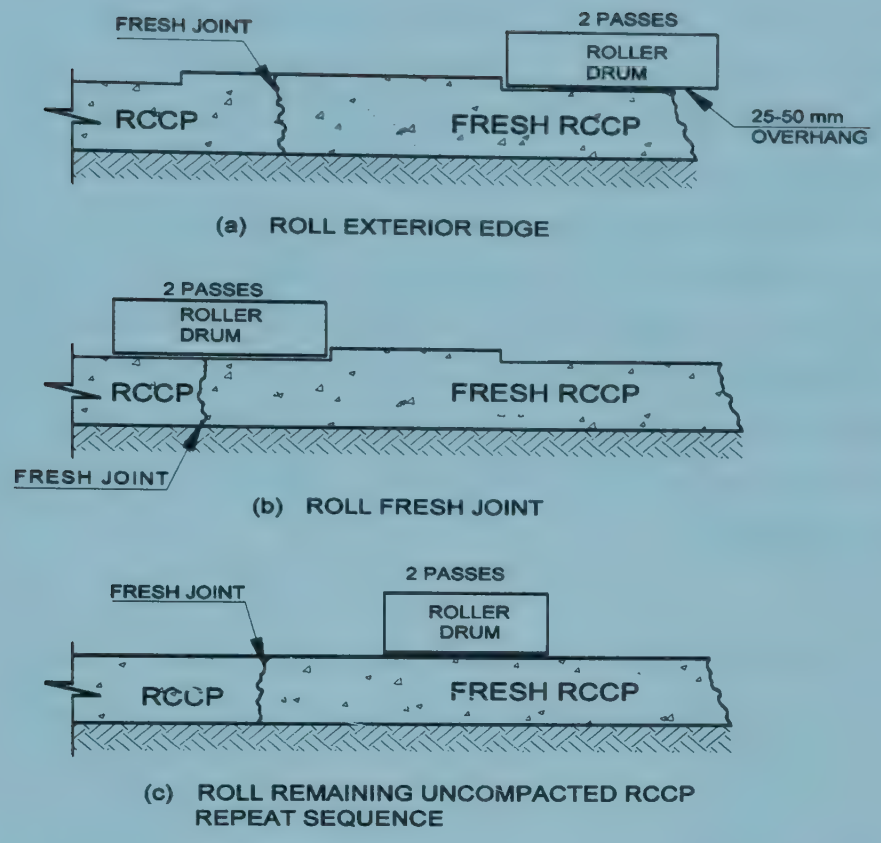

Fig. 3 Rolling Sequence for Second Adjacent Lane

6.8 Provision of Joints

There is a need to form both transverse and longitudinal joints and seal them like in the case of a normal concrete pavement to avoid the formation of random cracks. **Photo 5** shows a typical transverse crack expected to occur in RCCP due to shrinkage if joints are not sawn using a saw cut machine.

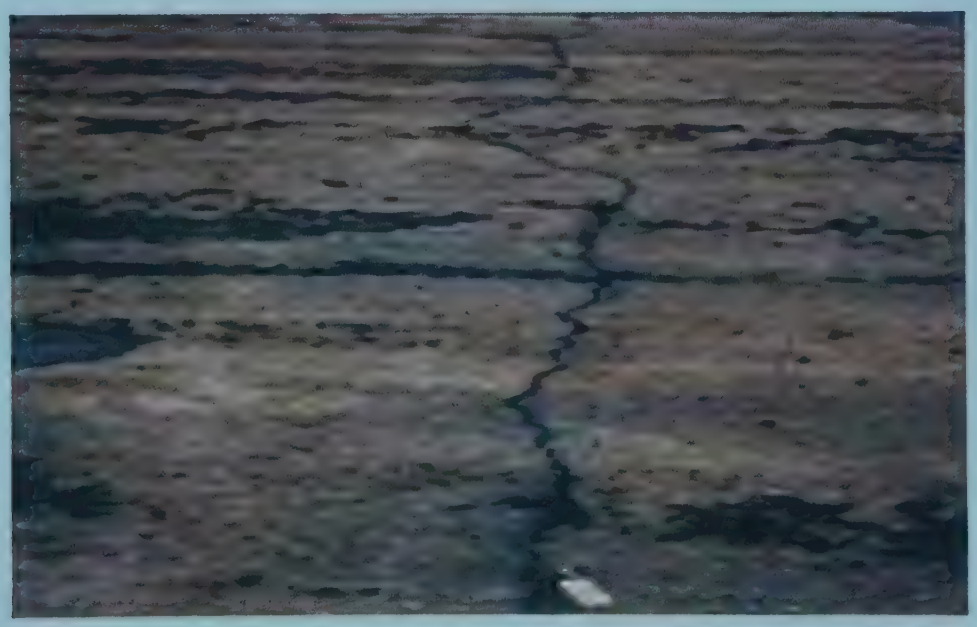

Photo 5 Transverse Shrinkage Crack in RCCP

6.8.1 *Transverse Contraction Joints*

Transverse cracks appear in the pavement due to shrinkage at a spacing of about 12 to 15 m apart depending on the quantum of moisture content in the mix, surface friction of GSB layer,

ambient temperature, and wind action etc. during paving operation. Therefore, it is necessary to cut transverse joints at a spacing of 4.5 m apart. The initial cut of about 3 mm width shall be made to 1/4 to 1/3 pavement depth. These joints can be formed after 5-6 hours after paving when the pavement surface is hard enough to take the load of saw-cutting equipment and when the joint edges are not chipped off during sawing. After first saw cut, a temporary seal of jute rope shall be inserted up to the depth of the cut. Subsequently the joints are widened as per the details shown in **Fig. 4** and sealed with hot rubberized bitumen sealant or cold polysulphide sealant. Before the application of sealant, the temporary seal is removed and the joint groove is cleaned thoroughly with compressed air to remove all the dirt and foreign matter. The joint spacing can, however, be varied based on the crack pattern observed in trial length construction in consultation with the Engineer.

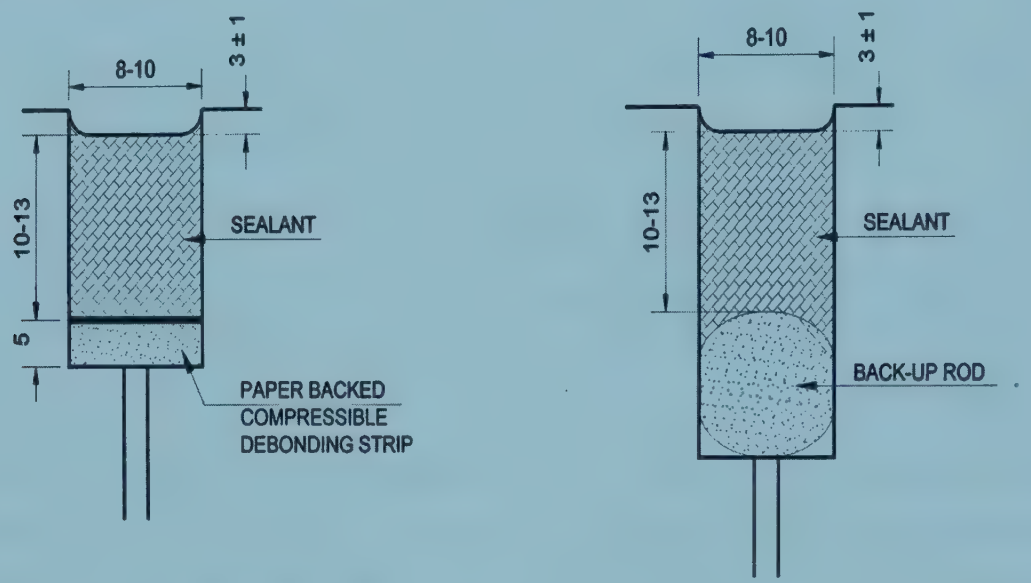

Fig. 4 Sealing Details for Transverse Joint

6.8.2 *Longitudinal Joint*

When a two-lane pavement of 7.0 m width is constructed, a longitudinal joint is introduced in the center. The joint shall be formed as per the details shown in **Fig. 5**. The joint can be sawn after 5-6 hours as in the case of transverse joints. The sealing operation is similar to the transverse joint but the joint configuration is slightly different as shown in **Fig. 5**.

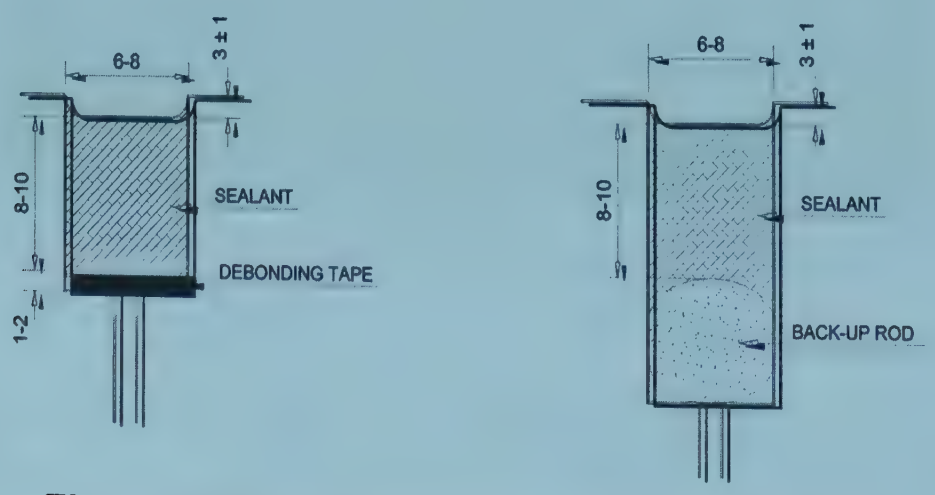

Fig. 5 Sealing Details for Longitudinal Joint

6.8.3 *Joints at the End of the Day's Work*

At the end of the day's work, the roller shall round off the end of the lane. The rounded edge is trimmed off with a saw cut machine to form a vertical face through the entire depth of the pavement. Such a measure helps in forming a proper transverse joint and subsequently sealing it. When the work is resumed the next day, the vertical face is moistened and the paver is backed into place, and set to proper direction by using shims sitting on top of the hardened concrete. After the paver lays the next day's work, a static pass is made in the transverse direction across the width of the pavement, and the joint carefully rolled to produce a smooth surface across the joint. A 3 m straight edge shall be used to check the level at the transverse joint. In case level at the joint is not satisfactory, it can be corrected by loosening the top of the rolled concrete by adding fresh concrete or removing excess concrete at joint.

If the concreting of the adjacent lane is delayed due to some reasons, a cold longitudinal joint is formed between the two lanes. In that case, the edge of the first lane shall be trimmed back to sound concrete to form a vertical face. The vertical face is dampened before laying concrete in the adjacent lane. The height of the screed shall be set to an elevation of approximately 25 percent higher than the desired thickness of the compacted concrete. The screed shall overlap the hardened concrete by 50 to 75 mm. The excess fresh concrete shall be pushed back to the edge of the fresh concrete lane with rakes so that a minimal amount of fresh material is left on the surface of the hardened concrete. The edge of the fresh lane shall be rolled first in the static mode with about 300 mm of the roller on the fresh concrete to form a smooth longitudinal joint.

6.9 Trimming of Edges

As no shuttering is used for containing edges on both sides of the RCCP, the sloping edges remain loose and honeycombed even after rolling operation is complete. During the rolling process the unrestrained edge gets squeezed out by a few centimeters. The loose mix at the edges has to be removed before constructing hard shoulders. The honeycombed edge if left as such can trap moisture during monsoon affecting the service life of the pavement. Trimming shall be done up to full depth with a saw cutting machine. Surveyor must mark the edge lines in advance for facilitating trimming operation satisfactorily. Marking of edges by a Surveyor will help in trimming of edges properly.

If hard shoulders are not provided then trimming of edges is not required.

6.10 Curing

Soon after the compaction is over depending upon the weather, wind velocity and humidity, curing shall start within one to two hours after laying by covering the roller compacted concrete pavement with the wet hessian in two-three layers for first 24 hours. After the first day curing, small earthen rectangles/dykes about 50 mm high transversely and longitudinally shall be made and shall be filled with water for at least 14 more days. In case of fly ash and slag admixed concrete, curing may be extended upto 16 days.

7. OPENING TO TRAFFIC

All vehicular traffic shall be kept off the RCCP for at least 28 days. Before opening the traffic all the joints will be cleaned and sealed.

8. QUALITY CONTROL

Adequate quality control shall be exercised in respect of strength of concrete. At least six beam and six cube specimens, three each for 7 days and 28 days strength testing shall be cast for every 150 cum (or part thereof) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered at site. Each pair shall be from a different delivery of concrete. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the requirements. The flexural strength test results shall prevail over compressive strength tests for compliance. A quality control chart indicating the strength value of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut from the concrete at such locations. The cores shall be cut at the rate of 2-cores for every 150 cum of concrete. The crushing strength of the cylindrical cores shall be converted to cube strength by using the following formula:

$$\textit{Core strength} = 0.8 \textit{ cube strength}$$

This formula applies for cores with a height to diameter ratio of 2. For ratios in the range of 1 to 2, the crushing strength of cores may be corrected by using the following formula:

$$f = 0.11\, n + 0.78$$

where f = correction factor to be applied to the core strength of specimens

n = height to diameter ratio of the core

The concrete in the pavement represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is at least equal to 85 per cent of the 28 day characteristic cube strength specified.

The in-situ density of concrete shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 sqm or part thereof of the pavement laid each day. The field density obtained shall be 98 percent of that achieved during the trial length construction. The density at both 0.5 m edges shall not be less than 96% of the density archived at the trial length construction.

The surface regularity of the finished pavement shall be checked by taking levels. The tolerance in surface levels shall be +5 mm and –6 mm. The maximum allowable difference between the road surface and the underside of a 3 m straight edge when placed parallel with, or at right angles to the center line of the road shall be 6 mm. Wherever required, humps can be corrected by grinding the surface with a grinder and low spots can be corrected by applying epoxy mortar.

APPENDIX I

MIX PROPORTION CALCULATIONS FOR ROLLER COMPACTED CONCRETE

Let the cementitious content of the mix be 16 percent of total dry weight (cementitious material plus dry aggregates). Fine and coarse aggregate content is taken as 45 percent and 55 percent respectively to satisfy the grading requirement of **Table 2**. Maximum dry density (MDD) and optimum moisture requirement (OMC) of the mix satisfying the strength requirement are determined to be 2375 kg/m^3 and 6.5 percent respectively.

Total dry weight of material	:	2375 kg
Cementitious material (16 %)	:	2375 x 0.16 = 380 kg
Fly Ash (25%)	:	380 x 0.25 = 95 kg
Cement (75%)	:	380 x 0.75 = 285 kg
Weight of aggregates (84 %)	:	2375 - 380 = 1995 kg
Weight of fine aggregate (45 %)	:	1995 x 0.45 = 897.750 kg
Weight of coarse aggregate (55 %)	:	1995 x 0.55 = 1097.250 kg
Water (6.5 %)	:	2375 x 0.065 = 154.375 kg

Different sizes of coarse aggregates are to be blended together to satisfy the grading requirement of **Table 2**.

(The Official amendments to this document would be published by the IRC In its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)

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